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Electrocardiographic parameters in clinically healthy Balouchi sheep

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Abstract

Electrocardiographic (ECG) parameters and cardiac rhythms have been evaluated and published in different breeds of beef and dairy cattle but there is limited information regarding these parameters in healthy sheep. This study is aimed to investigate the ECG parameters in Balouchi sheep. The ECG parameters including the amplitudes of P, Q, R, S and T waves, duration of P, QRS and T waves and P-R, Q-T and R-R intervals were evaluated in 44 male and female clinically healthy Balouchi sheep in standard and augmented limb leads (I, II, III, AVR, AVL, and AVF) and base-apex lead. The mean heart rate was 89.6 beats/minute which had a significant correlation with age (r=-0.269, *p*=0.014). Different configurations of P-wave, QRS complex and T wave were observed in different ECG leads. It was found that age and gender affects some ECG parameters. In some leads, rams had significantly higher amplitudes of P, Q, R, S and T waves and longer duration of PRR interval than ewes. Also in some leads, the amplitudes of P, R and S waves were significantly higher and the duration of QRS complex was shorter in sheep less than one year old than sheep with age three years or older. The most common cardiac dysrhythmia observed on the ECG traces was Sinus arrhythmia. Sheep with this dysrhythmia had a significantly lower heart rate ($p<0.05$). Also, it was concluded that the base-apex lead was the most suitable lead for ECG evaluation in sheep.

Keywords: Arrhythmia, electrocardiogram, Balouchi, sheep

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Introduction

Electrocardiography (ECG) has been introduced as a non-invasive diagnostic method for disturbances in the genesis and spread of the cardiac impulses (Escurdo *et al.*, 2009). In large animal medicine, ECG records have also been used as an accurate method in evaluation and comparison of cardiac function, and in diagnosis of cardiac arrhythmia and conduction abnormalities (Escudero *et al.*, 2009; Rezakhani *et al.*, 2004; Tajik *et al.*, 2010).

Although, ECG parameters and cardiac rhythms have been evaluated and published in different breeds of beef and dairy cattle (Rezakhani *et al.*, 2004), there is limited information regarding normal ECG parameters in healthy sheep. On the other hand, the importance of obtaining normal values of ECG for specific breeds of animals has also been emphasized (Escudero *et al.*, 2009).

Sheep population in Iran is 54 million heads, including 27 breeds and ecotypes. The Balouchi breed is one of the most important multi-purpose sheep breeds, and it constitutes about 30% of the total sheep population of Iran and plays an important role in meat and wool production (Dashab *et al.*, 2011) especially in the Khorsan Razavi province, Moreover, this breed has been considered for genetic improvement from several years ago. To the best of our knowledge, the normal ECG values in this breed are unjustified. This study was performed to evaluate these values, to compare different ECG leads, and to detect the probable effects of age and sex on normal ECG values in this breed.

Materials and methods

This study was performed on the Balouchi sheep kept on the Breeding and Research Centre of Balouchi Sheep in the north east of Iran (Mashhad, Abbas Abad) in September 2010. The ECGs were obtained from 44 clinically healthy pure Balouchi sheep. The animals used in this study were selected randomly and were divided into three groups consisting of 10 male and 10 female lambs (up to one year old), 12 ewes (1-5 years old) and 12 rams (1-4 years old). Also, the sheep were divided into three groups according to their age which are as follows: $G_1<1$ years, 1 years $\leq G_2<3$ years and, $G_3 \geq 3$ years.

The animals were reared under the same husbandry conditions in different group pens. After routine clinical examinations and taking vital signs (TPR), the ECGs were obtained from each sheep on seven leads including standard and augmented limb leads (I, II, III, aVR, aVL, aVF) and bipolar base-apex lead, using a single channel ECG machine (Suzuken, Kenz 110, Japan) with a paper speed of 25 mm/s and calibration of 10 mm equal to 1 mV. The ECG was recorded when the animals were thought to be in a quiet standing position using an alligator-type electrode attached to the skin. In the case of bipolar (I, II, III) and augmented (aVR, aVL, aVF) limb leads, the electrodes were connected to the skin of the medial sides of the elbows and stifles (Rezakhani and Edjtehadi, 1980). In the case of base-apex lead, the positive electrode of lead I (left arm) was attached to the skin of the fifth intercostal space just caudal to the olecranon and the negative electrode (right arm) on the jugular furrow about the lower 1/3 of the left side of the neck, and the earth was attached away from these two electrodes (Tajik *et al.*, 2010). Alligator clips were fixed to the skin after methyl alcohol application

A magnifying glass was used for analyzing and measuring ECG parameters. Using the glass, the precision of duration and amplitude were 0.02 s. and 0.05 mV, respectively. Heart rate was calculated by measuring the average six R–R intervals of each trace and the mean heart rate of 7 leads was used as the heart rate of each of the sheep. To describe the QRS complex, the first negative deflection was designated as Q, the first positive wave was named R and the negative deflection after R was designated as S, and a second upward

deflection in the same complex was labeled R'. If the QRS complex was a single negative deflection, it was described as the QS pattern. Lower case letters (q, r, and s) were used to indicate them, if the magnitudes of the waves were small (Deroth, 1980; Rezakhani *et al*. 2004). In the case of biphasic P or T waves (-/+ or +/-), the amplitudes of the two phases were summed.

Statistical analysis was performed using SPSS12 (Illinois, Chicago). Two sample *t* tests were used to detect differences in heart rate, waves' amplitude and duration, and P-R, Q-T and R-R intervals between the two sexes. Analysis of variance (ANOVA) tests were used for the comparison of the parameters between different age groups. Comparison of waves' conformation between the two sexes and different age groups were performed using Chi-square tests. Differences were considered significant at $p<0.05$.

Results

The common observed irregularity in the ECG of most sheep was sinus arrhythmia. Two sample *t* tests showed that sheep with sinus arrhythmia had a significantly lower heart rate in II, III, aVR, aVL and aVF leads ($p<0.05$).

Table 1. Heart rate and amplitudes of ECG waves in Balouchi sheep in 7 leads

Parameter / Lead	Heart rate	P (mv)	Q (mv)	R (mv)	S (mv)	T (mv)
I	93.6±3.237 (67-167)	0.046±0.004 (0.017-0.1)	0.324±0.082 (0.017-1.183)	0.039±0.007 (0.017-0.2)	0.348±0.045 (0.05-0.95)	0.147±0.014 (0.033-0.433)
II	92.1±3.03 (70-150)	0.044±0.008 (0.017-0.33)	0.169±0.025 (0.017-0.7)	0.101±0.064 (0.017-0.266)	0.192±0.211 (0.017-0.65)	0.118±0.081 (0.025-0.366)
III	90.5±2.652 (67-143)	0.034±0.007 (0.008-0.266)	0.049±0.006 (0.017-0.166)	0.296±0.026 (0.017-0.733)	0.091±0.075 (0.017-0.166)	0.09±0.075 (0.017-0.166)
aVR	89.5±2.405 (67-135)	0.04±0.003 (0.008-0.1)	0.018±0.001 (0.016-0.05)	0.249±0.03 (0.017-0.866)	0.059±0.007 (0.017-0.166)	0.134±0.015 (0.017-0.416)
aVL	87.8±2.628 (66-139)	0.034±0.002 (0.017-0.066)	0.139±0.044 (0.016-0.4)	0.024±0.016 (0.016-0.1)	0.331±0.205 (0.017-0.816)	0.107±0.011 (0.017-0.3)
aVF	87±2.15 (66-129)	0.029±0.002 (0.008-0.083)	0.086±0.011 (0.017-0.3)	0.165±0.017 (0.017-0.66)	0.108±0.054 (0.025-0.25)	0.103±0.009 (0.017-0.266)
BA	84.8±1.871 (67-124)	0.114±0.012 (0.05-0.5)	0.021±0.003 (0.01-0.1)	0.086±0.015 (0.02-0.42)	0.541±0.037 (0.1-1.06)	0.338±0.035 (0.12-1.1)

Table 2. Durations of ECG waves in Balouchi sheep in 7 leads

Parameter / Lead	P (sec)	QRS (sec)	T (sec)	P-R (sec)	Q-T (sec)	R-R (sec)
I	0.036±0.002 (0.02-0.06)	0.039±0.001 (0.02-0.073)	0.068±0.006 (0.04-0.28)	0.106±0.003 (0.07-0.16)	0.279±0.004 (0.22-0.333)	0.668±0.02 (0.36-0.9)
II	0.042±0.013 (0.02-0.066)	0.057±0.013 (0.033-0.1)	0.063±0.013 (0.04-0.1)	0.105±0.019 (0.06-0.16)	0.289±0.024 (0.226-0.33)	0.674±0.115 (0.4-0.855)
III	0.038±0.002 (0.02-0.08)	0.051±0.001 (0.04-0.073)	0.058±0.002 (0.033-0.085)	0.099±0.003 (0.06-0.146)	0.289±0.004 (0.204-0.34)	0.682±0.017 (0.42-0.89)
aVR	0.041±0.002 (0.026-0.073)	0.046±0.002 (0.026-0.073)	0.061±0.002 (0.026-0.1)	0.1±0.002 (0.06-0.14)	0.286±0.004 (0.233-0.346)	0.687±0.016 (0.445-0.89)
aVL	0.037±0.002 (0.02-0.06)	0.043±0.002 (0.026-0.06)	0.064±0.006 (0.02-0.28)	0.098±0.003 (0.06-0.133)	0.294±0.004 (0.233-0.36)	0.704±0.017 (0.445-0.905)
aVF	0.038±0.0018 (0.02-0.06)	0.052±0.001 (0.04-0.066)	0.06±0.002 (0.02-0.08)	0.099±0.002 (0.073-0.133)	0.295±0.004 (0.22-0.36)	0.704±0.015 (0.495-0.91)
BA	0.045±0.002 (0.03-0.08)	0.055±0.009 (0.03-0.4)	0.064±0.003 (0.01-0.11)	0.127±0.014 (0.08-0.68)	0.293±0.004 (0.24-0.36)	0.717±0.014 (0.48-0.89)

The mean heart rate ranged from 71.9 to 136 beats/minute with an average of 89.6. The ewes had higher heart rate than the rams in all measured leads, which was statistically significant in base-apex lead ($p < 0.05$). There was no significant difference between different age groups in the heart rate but it had a significant correlation with age (r=-0.269, p=0.014).

Table 3.Configurations of P and T waves in Balouchi sheep in 7 leads

Shape / Lead	(+)	(-)	(+/-)	(-/+)	(+/+)	flat	(+)	(-)	(+/-)	(-/+)	flat
I	37 (90.2%)	-	1 (2.4%)	2 (4.9%)	-	1 (2.4%)	21 (51.2%)	10 (24.4%)	-	9 (22%)	1 (2.4%)
II	31 (75.6%)	1 (2.4%)	7 (17.1%)	2 (4.9%)	-	-	6 (14.6%)	31 (75.6%)	3 (7.3%)	1 (2.4%)	-
III	10 (24.4%)	16 (39%)	7 (17.1%)	3 (7.3%)	1 (2.4%)	4 (9.8%)	7 (17.1%)	27 (65.9%)	5 (12.2%)	-	2 (4.9%)
avR	2 (4.9%)	29 (70.7%)	6 (14.6%)	3 (7.3%)	-	1 (2.4%)	23 (56.1%)	12 (29.3%)	6 (14.6%)	-	-
avL	32 (78%)	3 (7.3%)	3 (7.3%)	2 (4.9%)	-	1 (2.4%)	23 (56.1%)	8 (19.5%)	1 (2.4%)	8 (19.5%)	1 (2.4%)
avF	23 (56.1%)	2 (4.9%)	9 (22%)	3 (7.3%)	-	4 (9.8%)	6 (14.6%)	33 (80.5%)	1 (2.4%)	1 (2.4%)	-
BA	34 (82.9%)	-	-	5 (12.2%)	2 (4.9%)	-	35 (85.4%)	-	-	6 (14.6%)	-

The results of the measurement of the heart rate, the mean and ranges of P, Q, R, S and T waves amplitudes, and the mean and ranges of *P*, QRS, T, P-R, Q-T and R-R intervals of the sheep are shown in Table 1 and Table 2.

The configurations of P wave in leads I, II, aVL, aVF and base-apex were mainly simple positive, and in leads III and aVR were mainly simple negative. A biphasic P wave (-/+ or +/-) was observed in all leads. A notched P wave was diagnosed in leads III and base-apex (Table 3). There was no significant difference between the two sexes as well as different age groups in the configurations of P wave.

The rams had higher mean P amplitude than the ewes in all the measured leads, which was statistically significant in aVF lead ($p < 0.05$). The G_3 group had lower mean P amplitude in all leads, and in lead aVF, G_3 and G_2 groups had significantly lower mean P amplitudes than G_1 group.

There was no significant difference between the two sexes and between different age groups in P duration in different measured leads.

Seventeen different patterns of QRS complex were observed in ECGs. In total, 7 patterns in lead I; 3 patterns in lead II; 4 patterns in lead III; 10 patterns in lead aVR; 7 patterns in aVL; 3 patterns in aVF and 3 patterns in base-apex lead were observed (Table 4). The configurations of QRS complex had significant difference between the two sexes in leads III and base-apex ($p<0.05$). There was no significant difference between different age groups.

Male sheep had a higher Q amplitude in comparison with females in all 7 leads, which was statistically significant in leads I, II, aVF ($p<0.05$). R wave amplitude of rams was significantly higher than ewes in leads II, III and aVR. In leads I and base-apex, rams had significantly higher S wave than ewes.

In comparison between different age groups, Q amplitude showed no significant difference. G_3 had lower R amplitude than other age groups in leads III, aVR and aVF. S wave amplitude was significantly higher in G_1 than G_3 in aVL

Table 4.Configurations of QRS complex in Balouchi sheep in 7 leads

Shape / Lead	QR	Qr	qR	QS	QRS	QRs	QrS	qRS	qRs	qrS	R	RS	Rs	rs	Rare shapes
I	5 (12.2%)	5 (12.2%)	1 (2.4%)	4 (9.8%)	-	-	3 (7.3%)	-	-	1 (2.4%)	-	-	-	22 (53.7%)	-
II	31 (75.6%)	-	-	-	-	1 (2.4%)	-	-	-	-	-	-	-	-	9 (22%)
III	20 (48.8%)	-	19 (46.3%)	-	-	-	-	-	1 (2.4%)	-	-	-	-	-	1 (2.4%)
avR	-	-	2 (4.9%)	-	2 (4.9%)	-	-	14 (34.1%)	12 (29.3%)	-	2 (4.9%)	5 (12.2%)	1 (2.4%)	1 (2.4%)	2 (4.9%)
avL	-	-	2 (4.9%)	5 (12.2%)	-	-	-	1 (2.4%)	1 (2.4%)	4 (9.8%)	-	1 (2.4%)	-	27 (65.9%)	-
avF	26 (63.4%)	-	11 (26.8%)	-	-	-	-	-	-	-	-	-	-	-	4 (9.8%)
BA	-	-	-	-	2 (4.9%)	-	-	22 (53.7%)	-	17 (41.5%)	-	-	-	-	-

In lead II, III and aVF, QRS complex duration was significantly higher in G_3 than G_1. Also, G_3 had significantly higher QRS complex duration than other age groups in lead I.

Female sheep had significantly higher QRS complex duration than male sheep in leads II, III, aVR and aVF.

The configurations of T wave in leads I, aVR, aVL and base-apex were mainly simple positive, and in leads II, III and aVF were mainly simple negative. In all leads, a biphasic T wave was observed (Table 2). T wave configurations had a significant difference between the two sexes in base-apex lead ($p<0.05$).

In base-apex lead, rams had a significantly higher T amplitude than ewes. There was no significant difference between different age groups. T duration showed no significant difference between different sexes and age groups.

P-R interval was significantly longer in rams than ewes in lead II, aVR, aVL and aVF ($p<0.05$). In aVL lead, G_1 had significantly shorter P-R interval than other age groups.

Although, rams showed a longer R-R interval in comparison to ewes in all leads, the differences were not statistically significant ($p>0.05$). G_1 had a significantly shorter R-R interval than G_3 in leads aVL and base-apex.

In all leads, Q-T interval showed no significant difference between the two sexes ($p>0.05$). In base-apex lead, G_1 had a significantly shorter Q-T interval than G_3.

Discussion

There are few previous studies regarding normal ECG parameters in healthy sheep. According to the results, sinus arrhythmia was diagnosed in 89.9% of Balouchi sheep and those sheep had lower heart rate than sheep with normal rhythm. Rezakhani and Edjtehadi (1980) found sinus arrhythmia as a common irregularity in fat-tailed sheep, which is more prevalent in sheep with lower heart rates. In other studies, sinus arrhythmia has been reported in 23-33% of sheep (Pourjafar *et al*., 2011; Torio *et al*., 1997).

The mean heart rate of Balouchi sheep was 89.6 beats/minute which was within the reported normal range of sheep (60-160) (Smith *et al*., 2009), and was higher than that reported in Garole sheep breed (Ahmed and Sanyal, 2008) and lower than that reported in non-specified breed of fat-tailed sheep (Rezakhani and Edjtehadi, 1980).

The P wave configurations in leads I, II, aVL, aVF in Balouchi sheep were mainly simple positive, and in leads III and aVR were mainly simple negative. Additionally, a biphasic P wave was observed in all leads. Rezakhani and Edjtehadi (1980) reported same results in non-specified breed of fat-tailed sheep. According to our results, in base-apex lead, the main P wave configuration was simple positive. Similar results have been reported in Gallega sheep in base-apex lead (Torio *et al*., 1996).

According to our result, the Balouchi rams had higher P and QRS components amplitudes than the ewes. Higher P amplitude in male animals than females has been also reported in

horses and donkeys (Scudero *et al*., 2009). Higher myocardial mass in male animals may cause higher P, Q, R and S wave amplitudes. In Balouchi sheep, G_3 group had lower P, R and S amplitudes. Tovar *et al*. (1985) reported a negative correlation between age and P wave amplitude in merino sheep. In camels, higher S amplitude has been reported in younger animals than the old animals (Pourjafar *et al*., 2011). It is believed that gradual development of body mass may cause difficulty in the waves reaching the body surface in adults (Pourjafar *et al*., 2011).

In Balouchi sheep, G3 had higher QRS complex duration than G_1. Similar results have been reported in dairy cattle (Rezakhani *et al*., 2004) and horses (Physick e*t al*., 1983). Concurrent increment in myocardial mass in relation to development of body mass has been proposed as the probable cause of higher QRS complex duration in older animals (Physick e*t al*., 1983).

In the present study, T wave configuration and amplitude showed significant differences between both sexes and different age groups in Balouchi sheep. Similar results have been reported for donkeys (Scudero *et al*., 2009). However, it is believed that T wave is the most variable wave in ECG and it could be influenced by several factors such as animal excitement, drugs, vagal tone and etc. (Marr, 1999; Holmes & Rezakhani 1975).

There are little previous studies regarding the effects of age and sex on ECGs intervals in animals. We found longer P-R interval and R-R interval in Balouchi rams than ewes. Alidadi *et al*. (2002) reported longer P-R and Q-T intervals in Turkmen stallions than mares. In Balouchi sheep, G_1 showed lower P-R, R-R and Q-T intervals than G_3. Similar results have been reported for horses (Razavizadeh, 2007; Alidadi *et al*., 2002) and camel (Pourjafar *et al*., 2011). Larger myocardial mass in adults has been proposed as the probable cause (Pourjafar *et al*., 2011).

According to our results, less configuration variation and higher amplitude of waves in base-apex lead make ECG interpretation easier and more accurate, and candidate this lead as the preferred lead for ECG evaluation in sheep. Pugh (2002) has also recommended the base-apex lead for the ECG evaluation of sheep.

The finding of the present study can be used in diagnosis of ECG abnormalities in this breed.

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تعیین پارامترهای الکتروکاردیوگرافی در گوسفندان سالم نژاد بلوچی

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چکیده

پارامترهای الکتروکاردیوگرافی و ریتم قلبی در گاوهای شیری و گوشتی به فراوانی مطالعه شده است ولی در مورد گوسفند اطلاعات موجود در این زمینه محدود است. این مطالعه با هدف تعیین پارامترهای الکتروکاردیوگرافی و ریتم قلبی در گوسفندان نژاد بلوچی انجام شد. در 44 راس از گوسفندان نر و ماده نژاد بلوچی بظاهر سالم از نظر بالینی، پارامترهای الکتروکاردیوگرافی شامل ارتفاع امواج P، Q، R، S و T و مدت زمان امواج P، QRS و T و فواصل P-R ، Q-T و R-R در اشتقاق‌های اندامی استاندارد و تقویت شده (I، II، III، aVR، aVL و aVF) و اشتقاق قاعده‌ای- رأسی اندازه‌گیری شد. میانگین ضربان قلب 89/6 ضربه در دقیقه برآورد گردید که از همبستگی معنی‌داری با سن برخوردار بود(r=-0/269، P=0/014). در اشتقاق‌های مختلف، الگوهای مختلفی از امواج P، QRS و T مشاهده شد. سن و جنس دو مؤلفه ی تأثیر گذار بر برخی شاخص های الکتروکاردیوگرافی بودند به طوری‌که در برخی اشتقاق‌ها، ارتفاع امواج P، Q، R،S و T و طول فاصله ی P-R در گوسفندان نر به طور معنی داری بیشتر از گوسفندان ماده بود. همچنین، در گوسفندان گروه سنی کمتر از 1 سال در برخی اشتقاق‌ها ارتفاع امواج P، R و S به طور معنی داری بیشتر و مدت زمان مجموعه ی QRS به طور معنی داری کمتر از گروه سنی 3 ≤ سال بود. میزان وقوع آریتمی سینوسی در گوسفندان بلوچی بسیار بالا بود. در دام‌های دچار آریتمی سینوسی، میانگین ضربان قلب به طور معنی داری کمتر از دام‌های فاقد این آریتمی بود. همچنین این مطالعه نشان داد که مناسب‌ترین اشتقاق جهت ارزیابی الکتروکاردیوگرافی در گوسفند، اشتقاق قاعده‌ای- رأسی می‌باشد.

واژگان کلیدی: آریتمی، الکتروکاردیوگرافی، بلوچی، گوسفند